

METHOD AND SYSTEM FOR DISTRIBUTING DATA  
COMMUNICATIONS UTILIZING A CROSSBAR SWITCH

TECHNICAL FIELD OF THE INVENTION

This invention relates in general to the field of data communications and, more particularly, to a system for distributing data communications utilizing a crossbar switch.

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BACKGROUND OF THE INVENTION

The growth of the Internet has increased the demand for bandwidth. Digital subscriber line (DSL) technology meets this demand by providing higher bandwidth data service to subscribers. Particular installation of DSL technology uses a crossbar switch to provide a variable connection between a data switch, such as a DSL multiplexer (DSLAM) unit, and the lines connected to the subscribers.

Some conventional methods of providing DSL service utilize relay-based crossbar switches which may have slow switching times and short working lives. For example, the average switching frequency in such switches may be approximately one switch per day. Furthermore, extra manpower may be required to reconfigure the switch each time a new subscriber chooses to subscribe.

SUMMARY OF THE INVENTION

The present invention provides a system for distributing data communications utilizing a crossbar switch that substantially eliminates or reduces at least  
5 some of the disadvantages and problems associated with previous systems for distributing data communications.

In accordance with a particular embodiment of the present invention, a solid-state crossbar switch for transmitting data traffic includes a first number of  
10 input ports. Each input port is operable to receive DSL data from a data switch. The crossbar switch also includes a second number of output ports. Each output port is capable of being coupled to a customer premise equipment (CPE) device. The crossbar switch includes a  
15 third number of  $1 \times N$  solid-state analog switches. Each  $1 \times N$  solid-state analog switch is operable to couple one of the input ports with  $N$  output ports. Each input port may be coupled to one of the analog switches. The second number of output ports may be greater than  $N$ . The  
20 crossbar switch may include a sweeper port coupled to each output port. The sweeper port is operable to monitor each output port to detect an active connection of a CPE device to one of the output ports.

In accordance with another embodiment, a method for  
25 transmitting DSL data between a data switch and a CPE device using a solid-state crossbar switch includes receiving DSL data from the data switch at a first number of input ports. The method also includes receiving the DSL data from the input ports at a second number of  $1 \times N$   
30 solid-state analog switches. Each  $1 \times N$  solid-state analog switch comprises  $N$  outlets. The method includes switching the DSL data received at each analog switch to

an outlet of each analog switch. The method also includes receiving the switched DSL data at a third number of output ports. Each output port is capable of being coupled to a CPE device.

5        Technical advantages of particular embodiments of the present invention include a crossbar switch for the provision of data services utilizing solid-state technology. Accordingly, switching times of the crossbar switch may be improved, and its working life may be  
10    increased.

Another technical advantage of particular embodiments of the present invention includes a crossbar switch in which each input port is not coupled to each output port. Thus, time and expense associated with the  
15    manufacturing, installation and operation of the crossbar switch may be reduced since less components may be required to produce the crossbar switch.

Still another technical advantage of particular embodiments of the present invention is a crossbar switch  
20    for data services with a sweeper port for detection and self-provisioning of new subscribers to the services. Accordingly, less manual resources may be required each time a new subscriber chooses to subscribe to the data services being provided.

25        Other technical advantages will be readily apparent to one skilled in the art from the following figures, descriptions and claims. Moreover, while specific advantages have been enumerated above, various embodiments may include all, some or none of the  
30    enumerated advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of particular embodiments of the invention and their advantages, reference is now made to the following descriptions, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 illustrates a system for providing data services with a crossbar switch, in accordance with an embodiment of the present invention;

FIGURE 2 illustrates a solid-state crossbar switch, in accordance with an embodiment of the present invention;

FIGURE 3 illustrates a coupling table of a crossbar switch, in accordance with an embodiment of the present invention;

FIGURE 4 illustrates a coupling table of a crossbar switch with a sweeper port and a catcher port, in accordance with an embodiment of the present invention; and

FIGURE 5 illustrates a coupling table of a full crossbar switch with a sweeper port, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIGURE 1 illustrates a system 10 for providing data services, in accordance with an embodiment of the present invention. System 10 may provide data services, such as Long Reach Ethernet (LRE) service, for a subscriber community 22, which may include one or more businesses, apartment complexes or other communities in which subscribers share communications infrastructure or resources, such as a crossbar switch 12. Each subscriber in subscriber community 22 may access data services using one or more associated personal computers (PCs) 24, as illustrated, or other suitable devices, such as telephones or televisions, for interfacing with a data network, such as wide area network (WAN) 26.

System 10 includes a solid-state crossbar switch 12 which couples a data switch 16 with customer premises equipment (CPE) devices 20. Data switch 16 is linked to WAN 26 and may be a DSLAM unit or other device for routing or aggregating data traffic communicated between WAN 26 and PCs 24. For purposes of this specification, "data" includes any audio, video, multimedia, telecommunication signals or other type of data or other wideband or broadband calls, traffic or other signals that may be communicated between WAN 26 and PCs 24. In particular embodiments, data switch 16 may be any type of switch providing DSL service (DSL switch), such as a very high speed DSL (VDSL) switch.

Crossbar switch 12 includes input ports 14 coupled to data switch 16 and output ports 18 coupled to CPE devices 20. Crossbar switch 12 enables subscribers of subscriber community 22 to access data services through output ports 18. Crossbar switch 12 has a greater number

of output ports 18 than input ports 14 since it may not be economical to provision a data port for each potential subscriber. In the illustrated embodiment, crossbar switch 12 includes four input ports 14 and twelve output ports 18, but other embodiments of the present invention may include a crossbar switch having any number of input ports 14 and output ports 18. For example, particular embodiments may include a crossbar switch having twenty-four input ports and ninety-six output ports, while other embodiments may include a crossbar switch having sixteen input ports and sixty-four output ports.

Each input port 14 may be coupled internally within crossbar switch 12 to all or less than all output ports 18. If each input port 14 is coupled to each output port 18, then crossbar switch 12 is a "full" crossbar switch. If an input port 14 is coupled to less than all output ports 18, then crossbar switch 12 is a "partial" crossbar switch. A partial crossbar switch may save manufacturing time and costs since the switch will not require technology to couple each input port to each output port.

Since crossbar switch 12 is a "solid-state" crossbar switch, it uses silicon transistor technology. Therefore, its switching time may be faster and its working life may be longer than that of mechanical, relay-based switches. For example, the switching time of crossbar switch 12 may be approximately one switch per millisecond.

FIGURE 2 illustrates a crossbar switch 40 in accordance with a particular embodiment of the present invention. Crossbar switch 40 includes x number of input ports 42, and zz number of output ports 44. Each input port 42 is coupled to a 1 x 16 bi-directional analog

switch 46, which has one inlet and sixteen outlets. A 1 x 16 analog switch is operable to couple bi-directional data traffic through its inlet and switch the data traffic to any one of its sixteen outlets. Each 1 x 16 analog switch may be a solid-state analog switch.

Input ports of a crossbar switch in other embodiments may be coupled to other types of analog switches, such as 1 x N analog switches where N may be a number other than sixteen. For example, in other embodiments 1 x 12, 1 x 24 or 1 x 32 analog switches may be used. Analog switches with different N values may also be used in a single crossbar switch in particular embodiments. The decision regarding which types of analog switches to use in a particular embodiment may be made with a view towards reducing expenses and improving the provision of data services through the crossbar switch. Furthermore, some embodiments may include input ports not coupled to an analog switch.

In the illustrated embodiment, some analog switches 46 are coupled to a combiner 48. Each combiner 48 is coupled to an output port 44 of crossbar switch 40. Each combiner 48 may have varying numbers of inputs coupled to a number of analog switches 46 and one output coupled to an output port 44. Each combiner 48 is operable to couple bi-directional data traffic through any of its inputs.

Each analog switch 46 is coupled to either a combiner 48 or directly to an output port 44. Each combiner 48 is coupled to an output port 44 of crossbar switch 40. Thus, through the use of analog switches 46 and combiners 48, each input port 42 of crossbar switch



40 is coupled to sixteen output ports 44, and each output port 44 is coupled to at least one input port 42.

As illustrated and described above with regard to crossbar switch 12, input ports 14 and output ports 18, all of FIGURE 1, input ports 42 may be coupled to a data switch in order to provide data services from a WAN. Furthermore, output ports 44 may be coupled to CPE devices so that subscribers may access the WAN through PCs or other devices connected to the CPE devices.

Data traffic received at input port 42a may be transmitted to any one of output ports 44a, 44b, 44c, 44d, 44e, 44f, 44g, 44h, 44i, 44j, 44k, 44l, 44m, 44n, 44o and 44p (such group of output ports also referred to as 44a-44p). Similarly, as illustrated, data traffic received at input port 42b may be transmitted to any one of output ports 44b-44q. Furthermore, as illustrated, data traffic received at input port 42c may be transmitted to any one of output ports 44d-44s.

As an example, crossbar switch 12 may be used in the provision of internet service to homes of a subscriber community. Each input port 42 may be coupled to a DSLAM, and each output port 44 may be coupled to a home of the subscriber community. It may be very expensive to couple the DSLAM to all subscriber homes so that each home may be able to access internet service through the DSLAM at one time. Furthermore, it may be assumed that all homes in the subscriber community may not request internet service, and an internet service provider may not know which homes will and which homes will not request such service. Therefore, crossbar switch 12 may be used because it provides a way for each home to access the DSLAM while avoiding the expense of coupling the DSLAM to

each subscriber home in such a manner to allow each home to access internet service through the DSLAM at one time. Crossbar switch 12 also reduces the need for a technician to be sent out to make a manual connection between the DSLAM and a home each time a subscriber desires internet service (such sending out of a technician otherwise referred to as "truck roll").

In operation, a subscriber in a subscriber community may desire to access internet service through a DSLAM coupled to a WAN using a PC and a CPE device coupled to output port 44a. Since output port 44a is coupled to input port 42a and 42b, crossbar switch 40 may then establish an active connection whereby data traffic flows between input port 42a or 42b and output port 44a. As an example, assume an active connection is established between input port 42a and output port 44b.

Another subscriber from the same subscriber community may desire to access internet service through a DSLAM coupled to a WAN using a PC and a CPE device coupled to output port 44c. Output port 44c is coupled to input port 42a and 42b. Since an active connection is already established with input port 42a (and output port 42b), crossbar switch 40 would establish an active connection between input port 42b and output port 44c. Thus, crossbar switch 40 may establish an active connection, providing for the flow of data traffic, between any input port 42 and output port 44 coupled together which are not part of an established active connection.

FIGURE 3 illustrates a coupling table showing couplings between input ports 101-124 and output ports 201-296 of a crossbar switch having twenty-four input

ports and ninety-six output ports, in accordance with an embodiment of the present invention. In the coupling table, each input port 101-124 is represented with its own column, and each output port 201-296 is represented with its own row. A coupling between a particular input port and a particular output port is indicated with an "x" in the box where such input port's column and such output port's row intersect. For example, the table indicates that input port 105 is coupled to output ports 211-226. As illustrated, each input port is coupled to sixteen output ports. Furthermore, each output port is coupled to between one and six input ports.

In operation, the crossbar switch illustrated through the coupling table with input ports 101-124 and output ports 201-296 works much like crossbar switch 40 of FIGURE 2. As an example, a subscriber may desire to access a WAN through a PC and a CPE device coupled to output port 239. Assume, for this example, that input ports 109 and 110 are already part of an established active connection involving other output ports (for example, output ports 231 and 232, respectively). The crossbar switch would then establish an active connection between output port 239 and either input port 111 or 112. If crossbar switch established such a connection between output port 239 and input port 112, then input port 111 would still be available for an active connection to be established with any one of output ports 235-238 or 240-248.

FIGURE 4 illustrates a coupling table showing couplings between input ports 301-322, a sweeper port 323 and a catcher port 324 and output ports 401-496 of a solid-state crossbar switch, in accordance with an

embodiment of the present invention. In this embodiment, input ports 301-322 are each coupled to sixteen output ports. Sweeper port 323 is coupled to each output port 401-496, and catcher port 324 is coupled to each output  
5 port 401-496.

Sweeper port 323 fulfills a self-provisioning function of the crossbar. Sweeper port 323 continuously cycles through each available output port, establishing an active connection for a period of time (for example, a  
10 few milliseconds) with each such output port. An available output port is one that is not currently a part of an active connection with an input port. The purpose of this continuous cycling is to detect when a new subscriber, one that does not already have a subscription  
15 established with the WAN, connects with one of the output ports.

When sweeper port 323 detects a new subscriber connected to an output port through a CPE device, sweeper port 323 makes an active connection with that output  
20 port. The crossbar switch then reconfigures that active connection, establishing an active connection between the same output port and an input port other than sweeper port 323 (for example, one of input ports 301-322). After this active connection is established, sweeper port  
25 323 may return to its continuous cycling through available output ports looking for new subscribers. The self-provisioning function of sweeper port 323 can save labor time and expense because it prevents truck roll when a new subscriber desires to receive the data  
30 service.

Catcher port 324 helps to alleviate bad clusters in the crossbar switch. A bad cluster arises when there are

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no available input ports coupled to a particular output port through which a subscriber is trying to access a WAN.

For example, assume that input port 308 is presently  
5 part of an active connection with output port 432, input  
port 309 is presently part of an active connection with  
output port 433 and input port 310 is presently part of  
an active connection with output port 434. If a  
subscriber connected to output port 435 desires to access  
10 a WAN through the crossbar switch, there are no available  
input ports with which to make the connection, since  
input ports 308, 309 and 310 are presently part of an  
active connection. However, since catcher port 324 is  
coupled to each output port, catcher port 324 can form an  
15 active connection with output port 435. In this manner,  
catcher port 324 helps to alleviate bad clusters in the  
crossbar switch.

Catcher port 324 may continuously cycle through each  
available output port, establishing an active connection  
20 for a period of time (for example, a few milliseconds)  
with each such output port, much like sweeper port 323  
does in order detect a subscriber trying to access an  
output port with no available coupled input port. When a  
bad cluster arises and catcher port 324 forms an active  
25 connection with an output port to alleviate the bad  
cluster, the crossbar switch may alert technical support  
so that the couplings between the input ports and the  
output ports may be modified to reduce the chances of a  
bad cluster occurring in the future. The ability of  
30 catcher port 324 to alleviate the occurrence of bad  
clusters may allow a partial crossbar switch having input  
ports coupled to a reduced number of output ports to be

utilized. Accordingly, time and expenses associated with manufacturing the crossbar switch may be reduced. Furthermore, labor time and expense may be reduced since it may not be necessary for manual service to be provided  
5 each time a bad cluster situation arises.

It should be understood that FIGURES 2, 3 and 4 illustrate example configurations of how input ports and output ports of crossbar switches in accordance with particular embodiments of the present invention may be  
10 coupled. Such example configurations were determined with a view towards reducing the chances of the occurrence of a bad cluster. Other embodiments of the present invention may include a crossbar switch with input ports and output ports coupled in ways other than  
15 as described in FIGURES 2, 3 and 4. Varying the manner in which input ports and output ports of a crossbar switch are coupled may include using different types of 1 x N analog switches, such as 1 x 12, 1 x 24 or 1 x 32 analog switches or a 1 x N analog switch where N is  
20 between 12 and 32. Using such analog switches may reduce expenses associated with manufacturing a crossbar switch in accordance with an embodiment of the present invention and may reduce the chances of a bad cluster occurrence. Various other ways of coupling input ports and output  
25 ports may be determined, for example, by statistical analysis to reduce the chances of a bad cluster occurring or in view of a particular subscriber community being serviced.

FIGURE 5 illustrates a coupling table showing  
30 couplings between input ports 501-507 and a sweeper port 508 and output ports 601-624 of a solid state crossbar switch, in accordance with an embodiment of the present

invention. In this embodiment, the coupling table illustrates couplings of a full crossbar switch. As stated above, a full crossbar switch is one in which each input port is coupled to each output port of the crossbar switch.

Since each input port 501-507 is coupled to each output port 601-624, the full crossbar switch may establish an active connection between any input port 501-507 and any output port 601-624. This alleviates the possibility that a bad cluster may arise since a subscriber will have access to each input port through any output port.

Sweeper port 508 operates in a similar manner as sweeper port 323 of FIGURE 4. Sweeper port 508 continuously cycles through each available output port, establishing an active connection for a period of time with each such output port. Thus, sweeper port is able to detect when a new subscriber connects with one of the output ports.

A full crossbar switch may include  $1 \times N$  analog switches coupled to each input port to couple each input port to each output port. In such cases, the crossbar switch with the  $1 \times N$  analog switches coupled to each input port may contain  $N$  number of output ports. For example, the crossbar switch whose couplings are illustrated in FIGURE 5 may include  $1 \times 24$  analog switches coupled to each input port 501-507 and sweeper port 508. In this case, each  $1 \times 24$  analog switch would be coupled to each output port 601-624.

The coupling table of FIGURE 5 illustrates a full crossbar switch having seven input ports, a sweeper port and twenty-four output ports. Other embodiments may

include a full crossbar switch having other numbers of  
input ports, sweeper ports and output ports. For  
example, particular embodiments may include a full  
crossbar switch having twenty-four input ports and  
5 ninety-six output ports.

Some embodiments of the present invention may  
include a crossbar switch with only one of a sweeper port  
or a catcher port. Other embodiments may include a  
crossbar switch having multiple sweeper ports and/or  
10 catcher ports.

Although the present invention has been described in  
detail, various changes and modifications may be  
suggested to one skilled in the art. It is intended that  
the present invention encompass such changes and  
15 modifications as falling within the scope of the appended  
claims.

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